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Original Article

Artigo Original

Relationship between clinical and instrumental assessment of the tongue in healthy young adults

Relação entre as avaliações clínica e instrumental da língua em adultos jovens

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Keywords

Tongue
Muscle Strength
Evaluation
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ABSTRACT

Purpose: To verify the association of tongue clinical evaluation aspects with quantitative evaluation of tongue force. **Methods:** A cross-sectional study was conducted with 48 healthy adults, 13 men and 35 women (ages 20–44 years; mean – M=24.8 years; standard deviation – SD=5.3 years). By clinical evaluation, the following aspects were checked: tongue force, alternate movements, snap, suction and vibration of the tongue. The evaluator also checked if the floor of the mouth elevated during tasks of tongue elevation and sucking tongue on palate and the occurrence of lingual tremor. Quantitative evaluation was accomplished using the FORLING instrument. It is composed of a piston/cylinder assembly attached to a mouthguard and to a drive shaft. The force applied by the tongue to the drive shaft is hydraulically transmitted to a pressure sensor. Mann-Whitney's test was used to verify whether there were differences in average and maximum forces according to the characteristics assessed. The test was performed at a 5% level of significance. **Results:** The aspects with the most frequent alteration were sucking tongue on palate and tongue vibration. Tremor had a higher occurrence during tongue movements. Elevation of the floor of the mouth in sucking tongue on palate was the only aspect associated with quantitative evaluation. **Conclusion:** The association between elevation of the floor of the mouth during sucking tongue on palate and quantitative evaluation can provide insight into the higher participation of the suprahyoid muscles in some participants in both tasks.

Descritores

Língua
Força Muscular
Avaliação
Sistema Estomatognático
Fonoaudiologia

RESUMO

Objetivo: Pesquisar a associação entre os aspectos da avaliação clínica da língua e avaliação quantitativa da força de protrusão da língua. **Métodos:** Foi realizada uma pesquisa transversal com 48 adultos saudáveis, 13 homens e 35 mulheres (idades entre 20 e 44 anos; média – M=24,8 anos; desvio padrão – DP=5,3 anos). Na avaliação clínica, os seguintes aspectos foram avaliados: força da língua, movimentos alternados, estalo, sucção e vibração da língua. O avaliador também verificou se o assoalho da boca elevava-se durante tarefas de elevação e sucção de língua no palato, bem como a ocorrência de tremor lingual. Para avaliação quantitativa da força da língua, utilizou-se o FORLING, o qual é composto por um conjunto pistão/cilindro acoplado a um bocal e a uma haste de acionamento. A força aplicada pela língua à haste é hidraulicamente transmitida a um sensor de pressão. Utilizou-se o teste de Mann-Whitney para verificar se havia diferenças nas forças médias e máximas, de acordo com as características avaliadas. Adotou-se nível de significância de 5%. **Resultados:** Os aspectos com maior número de indivíduos alterados foram sucção de língua no palato e vibração de língua. Tremor lingual teve alta ocorrência durante tarefas de mobilidade. Elevação do assoalho da boca durante sucção de língua no palato foi o único aspecto da avaliação clínica associado à avaliação quantitativa de força. **Conclusão:** A associação entre elevação do assoalho da boca durante sucção de língua no palato com a avaliação quantitativa de força pode indicar uma maior participação da musculatura supra-hióidea em determinados participantes em ambas as tarefas.

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INTRODUCTION

For a health treatment to be effective, it is necessary to perform accurate assessments to provide sufficient information for a correct diagnosis. In orofacial myology, a detailed clinical assessment of the structures and functions of the stomatognathic system will point to the therapeutic possibilities for each patient[1]. Studies refer to clinical evaluation as a research tool and a fundamental part of speech-language pathology evaluation[2-4], which can help the therapist to develop clinical reasoning and therapeutic planning.

The tongue, as an important structure of the stomatognathic system, needs a detailed assessment. Tongue clinical evaluation must include an investigation of morphological aspects, habitual posture, presence of asymmetries or trembling, force and mobility. Tongue alternate movements, snap, sucking tongue on palate and tongue vibration are some tasks which can help the evaluator to assess the tongue[5].

Tongue force is an important part of tongue clinical evaluation. Deficits in tongue muscle strength are found in patients with dysphagia[6,7] and dysarthria[8]. One common way to evaluate tongue force is by use of a wooden spatula. The speech-language pathologist asks the patient to push the tongue against the wooden spatula held vertically a few centimeters in front of his/her lips. The examiner rates the tongue as having normal, mildly weak, moderately weak or severely weak force. There are no standard norms for this test, and ratings are necessarily based on the professional's experience[9].

Quantitative assessment of tongue force can be made in association with clinical evaluation in order to minimize problems of examiner's subjectivity and allow the recording and analysis of incremental changes in force due to clinical interventions or degenerative processes. Previous research has found relationship between qualitative and quantitative evaluation of tongue strength[2]; however, we have not found studies that investigated the relationship between quantitative evaluation of tongue strength and the entire clinical evaluation of tongue performance. Knowledge about the influence of tongue weakness on its performance in clinical evaluation can help the speech-language pathologist to make easier and more accurate diagnoses of the tongue force.

This study investigated the association of some aspects of tongue clinical evaluation (alternate movements, snap, sucking, vibration and qualitative evaluation of force) with the quantitative evaluation of tongue force in forward direction.

METHODS

This research comprised an observational cross-sectional study conducted at the School of Medicine, Universidade Federal de Minas Gerais (UFMG), after approval by the Ethics Research Committee, n. 249/08.

Participants

The sample consisted of 48 healthy Brazilian participants, students and staff of UFMG — ages 20–44 years; mean – M=24.8 years; standard deviation – SD=5.3 years: 13 (27%) men and 35 (73%) women. We selected this age interval to exclude the effect of reduced muscle strength due to aging[10-12].

The inclusion criteria were:

1. being a native Portuguese speaker;
2. to be within the age group; and
3. to give written consent authorizing participation in the research.

The exclusion criteria were:

1. a malocclusion-type overbite, anterior crossbite or excessive overjet, or absence of teeth, that could prevent the correct inset of the apparatus into the mouth;
2. lingual frenulum alteration;
3. the use of upper and/or lower dentures;
4. neuromuscular or hormonal disorders; and
5. cognitive problems that affected language comprehension.

Clinical evaluation

The participants were invited to take part in the study through posters displayed in the institution. Each participant received a form containing personally identifiable information questions. Those participants who fitted the inclusion criteria and did not have the presence of any aspect considered an exclusion criteria underwent a clinical orofacial myofunctional evaluation by a professional with 15 years of clinical experience, working with patients with disorders of orofacial myology, and 8 years as a professor in orofacial motricity. The protocol for tongue evaluation used in this research was based on the orofacial myofunctional evaluation MBGR Protocol[13].

By clinical evaluation, the following aspects were checked: alternate movements, snap, suction and vibration of the tongue. Moreover, the evaluator verified the floor of the mouth during tests of tongue elevation and sucking tongue on palate, the occurrence of tremor, malocclusions or absence of teeth, and tongue force.

To evaluate tongue alternate movements, the evaluator asked the participant to perform the movements of tongue protrusion and retraction and to touch the tongue on the right and left lip region as well as on the central upper and lower lip. When the participant could not perform a movement, the aspect investigated was considered altered. The cases in which the participant performed a movement associated with jaw or lips were also reported.

For the snap task, the participant had to elevate the tip of the tongue toward the palate and make a quick suction movement. This generates a "clicking" sound. In suction test, the participants were asked to suction their tongue on their palate and maintain this tongue posture for five seconds. In tongue vibration task, the participant was asked to elevate the tip of his/her tongue toward the dental alveoli of the superior incisive teeth and vibrate it in the superior and posterior directions inside the oral cavity, making a trill sound.

In the tests of tongue snap, suction and vibration, the presence of asymmetries, low intensity of the sound produced by

the tongue, and decreased execution time of any movement were regarded as alterations. When the participant could not perform a movement, it was considered absent. During the tasks of tongue elevation and suction, the floor of the mouth was observed, and the cases in which it lifted during the tests were registered separately. All tongue mobility tasks were accomplished once. However, when the participant was not able to perform a movement, visual model was provided and the task was accomplished one more time.

Tongue tremor was marked as absent or present. When it was present, we noted whether it occurred in the usual position and/or during tongue movements and/or during the tasks against resistance.

Tongue force was clinically assessed by the anterior displacement of the tongue against resistance once, *i.e.* when the participant was asked to push the tongue against a wooden spatula. The evaluator classified tongue force as normal when tongue protrusion against the resistance made by the spatula was maintained without trembling and without deformation. The classification of reduced force in the anterior third was used when only the anterior region of the tongue showed deformation. Tongue force was considered slightly reduced when the tongue was able to perform protrusion force against a resistance made by the spatula, though there might be slight tremors and bending of the tongue upwards or downwards. Finally, the force was considered reduced when the muscles were weak, maintaining slight force against the resistance provided by the spatula, with shaking and/or deformation. The evaluator also recorded whenever reduced forces in the tongue apex were observed.

Instrumental evaluation

Quantitative assessment of tongue protrusion force was performed using FORLING, an instrument developed by the Biomechanical Engineering Group of UFMG[14-17]. In this method, tongue force is evaluated during protrusion as in subjective (qualitative) evaluation.

FORLING, shown in Figure 1, is composed of a piston/cylinder assembly attached to a mouthguard (América Artigos Esportivos, São José do Rio Preto, SP, Brazil) and to a drive shaft that connects it to the cylinder, which hydraulically transmits the force produced to a pressure sensor (model WTP-4010, Wärme, Arujá, SP, Brazil). The pressure sensor measurements are transmitted through a data acquisition device (model ADU100, Ontrak, Sudbury, Ontario, Canada) to a personal computer.

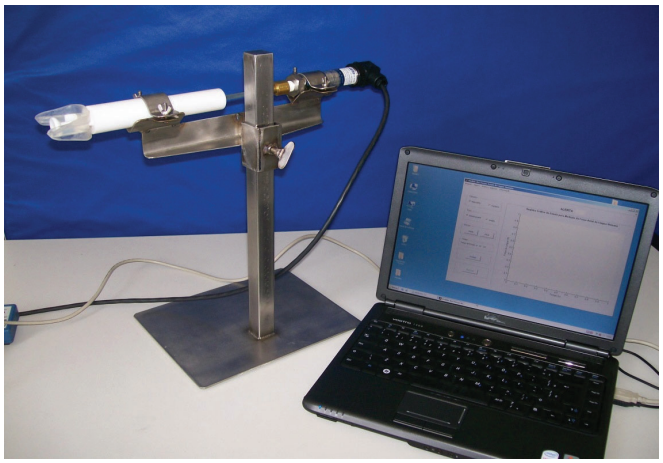

Figure 1. Overview of the measurement system

The evaluation was performed with the individuals sitting with their back and feet supported and hands resting on the base of the equipment. The instrument was fitted into the participant's mouth so that the teeth remained in the mouthguard. The mouthguard is used to keep the instrument attached to the mouth, to ensure that the participant's tongue position remained consistent throughout the evaluations and to control the level of mouth opening, as the extent of jaw separation might affect the compressive pressure the tongue is able to exert. This happens because the tongue is coupled with the mandible and could be moved forward by the mandible, which would potentially inflate the results[9].

A period of 15 seconds after test start was taken as adjustment time. After this, the program emitted a beep and the participant was asked to push the drive shaft of the plunger with the tongue, in a forward direction, with the greatest force that he/she was able to exert, holding it for ten seconds until hearing another beep. This procedure was performed three times, totaling four measurements at intervals of one minute; the first measurement was viewed as a practice exercise and was disregarded.

The computer calculated and registered the force-time history throughout the task. The transducer system was calibrated using standard weights at the Fundação Centro Tecnológico de Minas Gerais in Belo Horizonte, Brazil. The maximum uncertainty of the measurement system was ~0.18%[18].

The average and maximum forces of each participant were analyzed. The average force refers to the average of all forces measured for that participant in the three trials, while the maximum force refers to the average of the highest peaks of force in the three trials.

Data analysis

A nonparametric Mann-Whitney's test was used to verify whether there were differences in average and maximum forces according to the characteristics assessed, as data did not follow a normal distribution. The tests were performed at a 5% level of significance.

RESULTS

The mean maximum force of the 48 participants was 16.1±4.7 N and the mean average force was 11.6±3.4 N.

Figure 2 shows the boxplot of average and maximum forces. Maximum force showed higher variability of measurements compared with the average force.

Table 1 shows the frequency distribution, average and maximum force obtained by quantitative evaluation, and an association of forces for each aspect.

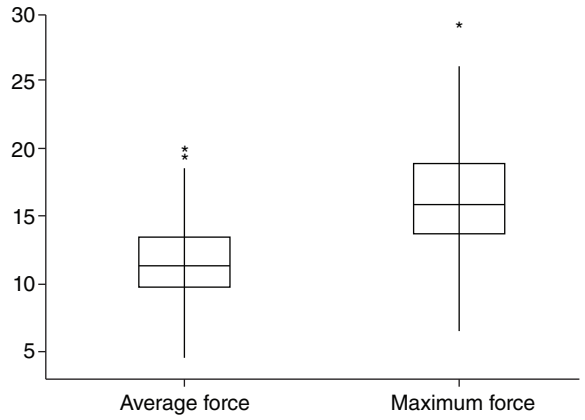

Figure 2. Boxplot of average and maximum tongue forces (N)

The tasks that involved the largest number of participants presenting alteration were sucking tongue on palate and vibration of the tongue (31.3% altered tasks for both categories). Tremor was observed in 43.8% of the sample, and 87% of tremor occurrence happened during tongue movements.

Average and maximum forces were compared among participants, with different results in each task. Difference was found only when comparing participants with and without elevation of floor of the mouth during the sucking tongue on palate task.

DISCUSSION

The tongue is a complex organ, consisting of intrinsic and extrinsic muscles, which performs several movements and participates in various functions of the stomatognathic system, such as swallowing and speech[19,20]. A consistent clinical evaluation of this structure, with tests that evaluate it in static and dynamic ways, as well as objectively, seems to be helpful for an accurate force and mobility diagnose and, consequently, for the establishment of a good therapeutic plan.

In this study, the mean of the maximum forces of the 48 participants was 16.1 N and the mean of the average forces was 11.6 N. In studies using the same instrument, these values were 22.8 and 16.0 N[14], 19.4 and 13.8 N[15], 15.9 and 11.4 N[16], and 18.9 and 13.3 N[17], respectively. A slight variation in the values among the studies using the same instrument was expected on account of the peculiarities of the different samples.

The clinical aspect that involved the smallest number of participants presenting alteration was tongue movements (protrusion, retraction, elevation and lowering). Average and maximum forces in these participants were similar to those obtained in the entire sample. It was not possible to analyze the statistical association of these variables owing to the small number of participants with alteration (one for each aspect assessed). Tongue protrusion was also adequately performed by most of the participants in a study of children aged 4–7.5 years[4]. The literature suggests that changes in tongue motion can interfere with the production of the phonemes and can consequently change the speech intelligibility of the subject. Farias et al. verified a significant relationship between tongue force and praxis in school participants[3].

When analyzing those tasks involving tongue movements, we verified associated movements of the lips in a single participant (2.1%), and these associated movements occurred in all directions (right, left, up and down). Maximum and average forces in this participant were 29.3 and 20.0 N, respectively. These values were higher than those produced by the entire sample. We believe that the associated movement is a muscular compensation that is concomitantly accomplished with the main movement with the aim of improving performance. Due to the small participant population, it is not possible to affirm that such lip movement behavior is really a compensation at this time. In this way, it would be important to confirm this hypothesis, in a larger sample.

Associated jaw movement occurred in 18.8% of the sample. Maximum and average forces were 16.3 and 11.1 N, respectively, when moving the tongue up and down. When the movement was to the left and right, 16.7% of the sample had associated jaw movement, and the maximum and average forces in these participants were 18.3 and 12.7 N, respectively. These values are slightly higher than those produced in participants without associated movement, which suggests that jaw movement can also be a compensation. Solomon and Munson[9] verified, by electromyography measurements, activation of mandibular elevators during tongue force tasks as an attempt to increase tongue pressure. The associated movements always occurred in pairs, in either a horizontal or a vertical direction. No participant had associated movement during tongue protrusion or retraction.

Regarding tongue snap, sucking tongue on palate and tongue vibration, we found that 12.5% of the participants had altered tongue snap, 31.3% had altered sucking and 31.3% had altered tongue vibration. We also observed that 2.1% of the entire sample were unable to perform the suction of tongue on palate and 4.2% were unable to vibrate their tongue. When associating these variables with maximum and average forces, we observed no associations for any aspect; however, we verified that the maximum and the average forces in those participants who were unable to perform tongue vibration were lower (11.4 and 7.5 N, respectively) than in participants who had altered vibration (16.9 and 12.2 N) or adequate vibration (16.3 and 11.9 N). The same was not observed for suction or snap. One study identified tongue vibration as the movement that subjects found more difficult to perform[4]. We found no studies that analyzed sucking tongue on palate and tongue snap.

The observation of the floor of the mouth's elevation during tongue elevation or during the sucking tongue on palate task seems to indicate the participation of suprahyoid muscles in these tasks. In this study, 31.3 and 12.5% of the participants had an elevated floor of the mouth during the tongue elevation and during the suction of the tongue on the palate, respectively. When comparing these findings with quantitative data, we observed a significant relationship between elevation of the floor of the mouth during suction of the tongue on the

Table 1. Association between variables of tongue clinical evaluation and measures of tongue force

Variable of tongue clinical evaluation	n (%)	Average force (N)	SD (N)	p-value*	Maximum force (N)	SD (N)	p-value*
Protrusion/retraction							
Adequate	45 (93.8)	11.5	3.4		15.9	4.7	
Altered	1 (2.1)	14.1	0	–	20.3	0	–
Missing	1 (2.1)	–	–		–	–	
Protrusion/retraction with associated movement							
No associated movement	48 (100.0)	11.6	3.4	–	16.1	4.7	–
With associated movement	0 (0.0)	0	0		0	0	
Elevation/lowering							
Adequate	47 (97.9)	11.6	3.4	–	16.1	4.7	–
Altered	1 (2.1)	12.1	0		16.1	0	
Elevation/lowering with associated movement							
No associated movement	38 (79.2)	11.5	3.1		15.7	4.1	
Associated jaw movement	9 (18.8)	11.1	3.8	–	16.3	5.5	–
Associated lip movement	1 (2.1)	20.0	0		29.3	0	
Lateralization							
Adequate	48 (100.0)	11.6	3.4	–	16.1	4.7	–
Altered	0 (0.0)	0	0		0	0	
Lateralization with associated movement							
No associated movement	39 (81.3)	11.2	3.2		15.3	4.3	
Associated jaw movement	8 (16.7)	12.7	3.4	–	18.3	3.4	–
Associated lip movement	1 (2.1)	20.0	0		29.3	0	
Tongue snap							
Adequate	42 (87.5)	11.4	3.3	0.066	15.9	4.7	0.151
Altered	6 (12.5)	13.4	3.9		17.7	4.4	
Sucking tongue on palate							
Adequate	32 (66.7)	11.8	3.1	0.656	16.0	4.1	0.945
Altered	15 (31.3)	11.3	4.2		16.1	5.9	
Absent	1 (2.1)	12.2	0	–	19.9	0	–
Vibration							
Adequate	30 (62.5)	11.9	3.1	0.895	16.3	4.3	0.727
Altered	15 (31.3)	12.2	3.5		16.9	4.8	
Absent	2 (4.2)	7.5	4.2	–	11.4	6.4	–
Missing	1 (2.1)	–	–	–	–	–	–
Elevation of the floor of the mouth during tongue elevation							
Present	31 (64.6)	11.8	3.7	0.439	16.5	5.2	0.497
Absent	15 (31.3)	11.1	3.0		15.2	3.6	
Missing	2 (4.2)	–	–	–	–	–	–
Elevation of the floor of the mouth during suction of the tongue							
Present	32 (66.7)	12.0	3.4	0.029**	16.7	5.0	0.021**
Absent	6 (12.5)	8.4	3.0		11.7	3.7	
Missing	10 (20.8)	–	–	–	–	–	–
Lingual tremor							
Present	21 (43.8)	11.8	3.4	0.691	16.2	4.8	0.956
Absent	25 (52.1)	11.6	3.6		16.1	4.8	
Missing	2 (4.2)	–	–	–	–	–	–
Classification of tongue force							
Normal	18 (37.5)	12.6	3.0	0.079	17.4	4.4	0.153
Altered	30 (62.5)	11.1	3.5		15.4	4.7	
Classification of tongue force – altered							
Reduced force in tongue apex	9 (30.0)	11.3	4.0		15.4	5.9	
Reduced force in anterior third	14 (46.7)	11.8	2.8	0.311	16.3	3.7	0.611
Slightly reduced force	2 (6.7)	11.4	7.6		14.2	7.0	
Reduced force	5 (16.7)	8.5	2.9		13.0	5.0	

*Mann-Whitney Test – numeric data not applicable (n insufficient for the test); **significant value

Caption: SD = standard deviation

palate and the maximum and average forces. Participants who presented elevation of the floor of the mouth during sucking tongue on palate attained higher values of force in quantitative evaluation. Palmer et al.[21] found a strong relationship between electrical activity of floor of the mouth muscles and the pressure exerted by tongue on palate, indicating that floor of the mouth's muscles contribute to generation of tongue force in an upward direction.

Tremor, defined as an involuntary oscillatory movement of the tongue, was observed in 43.8% of the sample. It is noteworthy that tremor was registered when it occurred more than once. Maximum force (16.2 and 16.1 N) and average force (11.8 and 11.6 N) of participants with and without tremor, respectively, were very similar. We did not verify any relationship between tremor and tongue force. In the literature, lingual tremor has mostly been associated with Parkinson's disease[22] and dystonia[23]. So, if tremor is noted, it is a good practice to conduct a detailed investigation about the possibility of a neurological condition; however, lingual tremor can also be observed in subjects without evidence of neurologic diseases, at rest, during a task and/or with orolingual structures in a certain position[23].

Clinical evaluation revealed that 62.5% of this sample had altered tongue force; however, minor alterations in force were considered during qualitative classification. It should be noted that, in 29.2% of the group, the weakness was only in the anterior third of the tongue and, in 18.8%, only the lingual apex was weak. Thus, minimum alterations in force may have no impact on the stomatognathic functions. Only 10.5% of the participants had an overall reduction in tongue force and 4.2% had a slight reduction in tongue force.

Tongue force values produced by participants with normal classification on clinical evaluation were higher than those produced by participants classified as having alteration in tongue force; however, in the present study, we found no relationship between the clinical (qualitative) and instrumental (quantitative) evaluation of tongue force. This finding can be justified by the fact that, in the present study, minor alterations in force in any region of the tongue were considered during qualitative classification. These minimum alterations were not distinguished by instrumental evaluation. Clark et al.[2] also compared subjective and objective evaluation of tongue force and, although maximum force tended to decrease as tongue was rated as weaker, they could only differentiate the "severely weak" from "normal" groups.

Other methods for tongue force evaluation are used by speech-language pathologists, but, in this research, we chose to evaluate tongue protrusion force because it is the same method used in quantitative evaluation with FORLING. In this way, we could compare the results. Protrusion force against resistance requires activation of the genioglossus and intrinsic protrudor muscles, with the former more important for establishing anterior-posterior tongue location and the latter playing a greater role in the generation of protrusive force[24].

The exclusion of participants with a force reduction only in the lingual apex had no impact on such relationships. Participants with reduced force only in the lingual apex produced smaller tongue forces in quantitative evaluation than those with normal, anterior third altered, or slightly reduced tongue forces, suggesting the necessity of analyze them separately.

In the literature, there is a lack of studies comparing the findings of tongue clinical evaluation with objective lingual force data. The fact that all participants in this study were clinically normal limited the range of performance; however, in order to evaluate pathophysiologic processes in the population, it is important to first evaluate normal changes in motor function. With this study, we suggest that, during clinical evaluation, the examiner observe the floor of the mouth in the task of sucking tongue on palate, as well as monitor it during myofunctional treatment due to its relationship with tongue force. One limitation of this study is the fact that the clinical evaluation of the tongue was accomplished by just one evaluator. Another limitation is that important information about the tongue, like width and thickness, as well as habitual position and its performance during functions were not analyzed. For future research, we suggest an increase in study's sample size and the inclusion of participants with orofacial myofunctional disorders to enhance the range of performance.

CONCLUSION

An association was found between floor of the mouth's elevation in suction of the tongue on palate and maximum and average tongue forces. We hypothesize that elevation of the floor of the mouth during tongue's elevation provide insight into the role of the suprahyoid muscles in increasing tongue force. Studies with larger sample sizes are needed to confirm these hypotheses.

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**BAR and ARM participated mainly at the collection and analysis of data and writing of the article; RMMMF participated in data analysis and writing of the article; EBLC participated in the drafting and critical revision of the article.*

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